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Functional architecture of photosynthetic light harvesting complexes

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Document Version

Publisher's PDF, also known as Version of record

Publication date:

2008

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Mozzo, M. (2008). *Functional architecture of photosynthetic light harvesting complexes*. s.n.

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Milena Mozzo

**FUNCTIONAL ARCHITECTURE
OF
PHOTOSYNTHETIC LIGHT
HARVESTING COMPLEXES**



This thesis was carried out in the Groningen Biomolecular Sciences and Biomolecular Institute of the University of Groningen (The Netherlands)

Printed by: Facilitair Bedrijf RuG, Groningen

Cover layout: Jean Paul D'Alife

ISBN: 978-90-367-3345-8

ISBN: 978-90-367-3344-1 (electronic version)

RIJKSUNIVERSITEIT GRONINGEN

Functional Architecture of Photosynthetic Light Harvesting Complexes

Proefschrift

ter verkrijging van het doctoraat in de
Wiskunde en Natuurwetenschappen
aan de Rijksuniversiteit Groningen
op gezag van de
Rector Magnificus, dr. F. Zwarts,
in het openbaar te verdedigen op
vrijdag 22 februari 2008
om 14.45 uur

door
Milena Mozzo

geboren op 8 september 1979
te Bovolone (VR), Italië

Promotor: Prof. dr. E. J. Boekema

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Beoordelingscommissie: Prof. dr. H. van Amerongen
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ISBN: 978-90-367-3345-8

Ai miei amici

Success!

Preface

Light is an electromagnetic radiation composed of elementary particles called photons and can be classified based on three primary properties: brightness, wavelength and polarization. Interaction of light with living matter is a fundamental topic in life sciences. The reason is easily explained: the Sun, the light source in our planet, permits development, sustenance and regulation of almost all form of life.

Among the different light-induced processes, photosynthesis is fundamental and unique because it enables the transformation of the light energy in chemical energy.

Beside the fascination of the curiosity-driven studies of photosynthesis, the unravelling of structural and functional organisation of the photosynthetic apparatus can offer the opportunity to mimic the process, with the aim of energy production.

Moreover, unveiling the role of individual complexes composing the light-converting machinery can allow identifying resistance and photoprotection mechanisms which allow photosynthetic organisms to adapt to climate changes.

This thesis exploits the properties of light for investigating the early processes of photosynthesis: light harvesting and photoprotection.

The main subjects of this study are the antenna complexes, that are chlorophylls-carotenoids binding proteins composing the photosynthetic apparatus. The antennae capture and efficiently transfer excitation energy to the reaction centre, where the first chemical reaction of the process takes place. Furthermore, in high light conditions, these complexes can efficiently dissipate the excess of harvested light energy, thus protecting the photosynthetic organisms from photo-damages.

The enormous progress in structure determination of membrane proteins, together with the development of spectroscopic methods of very high time resolution, offer the basis to get insight on the properties of antenna complexes.

Combining mutation analysis with spectroscopic measurements, the properties of pigments bound to the antenna complexes of green plants are determined. Moreover, the data are used as starting point for finely probing the pigment-protein environment of different antennae and investigating the roles of individual pigments, in light harvesting and photoprotection.

Milena Mozzo

Abbreviations and symbols

Abs, absorption

Asn (or N), asparagine

a.u., arbitrary units

ADMR, absorbance-detected magnetic resonance

ATP (or ADP), adenosine tri (or di-) phosphate

B_x, B_y, higher energy optical absorption bands (Soret band) of porphyrins

Car, carotenoid

¹Car*, ³Car*, lowest singlet and lowest triplet excited states of carotenoid

CD, circular dichroism

Chl, chlorophyll

¹Chl*, ³Chl*, lowest singlet and lowest triplet excited states of chlorophyll

CP *X*, chlorophyll binding protein of molecular mass *X*

Cyt, cytochrome

DM, n-dodecyl maltopyranoside

DNA, deoxyribonucleic acid

F, phenylalanine

Fd, ferredoxin

FDMR, fluorescence-detected magnetic resonance

FNR, ferredoxin NADP⁺ reductase

FWHM, full width at half maximum

Glu, glutamic acid

Gln, glutamine

H⁺, H₂ hydrogen ion and molecular forms

Hepes, n-2-hydroxyethyl-piperazine

His (or H), histidine

HPLC, high-performance liquid chromatography

IEF, isoelectrofocusing

KDa, kilo dalton

L (or Lut), lutein

L1, L2, carotenoid binding sites

LHCI (or Lhca) Light harvesting complexes of Photosystem I

LHCII (or Lhcb) Light harvesting complexes of Photosystem II

LT, low temperature

M, measurement

Mg, magnesium

N (or Neo), neoxanthin
 N1, carotenoid binding site
 NAD(P)⁺, NAD(P)H, nicotinamide adenine (phospho) dinucleotide (oxidized and reduced)
 nm, nanometer
 NPQ, non photochemical quenching
³O₂, ground state of molecular oxygen
¹O₂^{*} lowest singlet excited state of molecular oxygen
 O.D., optical density
 OPO, optical parametric oscillator
 ORF, open reading frame
 PC, plastocyanin
 P680, photochemically active pigment (or electron donor) of PSII
 P700, photochemically active pigment (or electron donor) of PSI
 pQE, pET, bacterial expression vectors
 PG, phosphatidylglycerol
 PQ, PQH₂ plastoquinone, plastoquinol
 PSI (II), Photosystem I (II)
 Psa *X*, subunit *X* of PSI RCs
 PsbS, 22KDa PSII protein
 qE, energy dependent quenching
 Q_x, Q_y, low energy absorption bands of porphyrins
 R, reference
 RC, reaction centre
 ROS, reactive oxygen species
 RT, room temperature
 S₁₋₀ or S₂₋₀, singlet excited states of chlorophylls
 SDS-PAGE, sodium dodecyl sulphate polyacrylamide gel electrophoresis
 TmS, triplet minus singlet
 V (or Viola), violaxanthin
 V1, carotenoid binding site
 WT, wild type
 w/v, weight per volume
 Z (or Zea), zeaxanthin
 Å, angstrom
 ε, molar extinction coefficient (M⁻¹ cm⁻¹)
 λ, wavelength (nm)
 τ, lifetime

Contents

CHAPTER 1: INTRODUCTION TO PHOTOSYNTHESIS	1
Part I	23
CHAPTER 2: PIGMENT-PIGMENT INTERACTIONS IN LHCA4 ANTENNA COMPLEX OF HIGHER PLANTS PHOTOSYSTEM I	25
CHAPTER 3: PROBING THE STRUCTURE OF LHCA3 BY MUTATION ANALYSIS	47
CHAPTER 4: ALL PHOTOSYSTEM II ANTENNA COMPLEXES POSSESS THE FINGERPRINTS OF THE NON-PHOTOCHEMICAL QUENCHING SITE	65
Part II	79
CHAPTER 5: SINGLET AND TRIPLET STATE TRANSITIONS OF CAROTENOIDS IN THE ANTENNA COMPLEXES (LHCA) OF HIGHER PLANTS PHOTOSYSTEM I	81
CHAPTER 6: PHOTOPROTECTION IN THE ANTENNA COMPLEXES OF PHOTOSYSTEM II: ROLE OF INDIVIDUAL XANTHOPHYLLS IN THE TRIPLET QUENCHING	103
Summary	125
Samenwatting	129
Acknowledgments	130

